

Fig.1B

## Description

[0001] This invention relates to an electrosurgical instrument and, in particular, to apparatus for converting a surgical instrument, such as a purely mechanical laparoscopic tool, for electrosurgical treatment.

[0002] In the field of laparoscopic surgical tools, the ability to deliver radio frequency electrosurgical power for coagulation is well known. It is also well known for laparoscopic tools to provide for mechanical manipulation or a mechanical function. Tools combining these attributes include metal instruments with insulated shafts that can be used as monopolar instruments. There are several problems with such tools. Firstly, monopolar power delivery can cause excessive tissue damage as a result of the long conductive pathways. This is particularly so when attempting to perform deep coagulation which involves high current delivery. A second problem is that such high current delivery stresses the electrical interface between tissue and electrodes, causing carbonisation and/or sticking. Yet another problem is that a metal instrument shaft can cause radio frequency energy to be capacitively coupled to entry ports or other closely coupled instruments.

[0003] One technique used in the prior art to overcome these problems is to use a bipolar instrument. In this case two electrodes are used to deliver electrical power to tissue. This localises the power distribution and lessens the danger of damage to adjacent structures. However, such instruments are more complicated, particularly when movable elements are required such as for forceps or scissors. Further, the depth of effect is determined by the spacing of the electrodes from each other.

[0004] It is an object of the present invention to provide an improved instrument.

[0005] According to a first aspect of this invention, an electrosurgical instrument comprises: an elongate inner tubular member having a proximal end and a distal end, at least a portion of the member being electrically conductive in order that there is d.c. electrical continuity between the said ends; and an elongate tubular electrically conductive sheath surrounding the inner member but spaced from the conductive material of the inner member to form an electrically insulative jacket, whereby the inner member and the sheath constitute a coaxial transmission line, the sheath being electrically connected to the inner member at a location spaced proximally from the distal end; a feeder connected to the inner member distally of the connection between the sheath and the inner member; and an r.f. isolating structure between the said connections of the inner member to the feeder and to the sheath, the isolating structure presenting a series impedance between the said connections at an operating frequency of the instrument.

[0006] The form of the isolating structure depends on the frequency of operation. In general, it is constituted by a resonant element or a resonant assembly of ele-

ments having a frequency of resonance corresponding to an operating frequency of the instrument. For comparatively high electrosurgical frequencies, typically upwards of 300MHz, the isolating structure consists of a section of the inner member between the connections to the sheath and the feeder, the section having an electrical length of  $m\lambda/4$ , where  $m$  is an odd number and  $\lambda$  is the wavelength associated with the operating frequency in question. Since, at the proximal end of this section, the sheath is coupled to the inner member at least at high frequencies, the section operates as an impedance transformer presenting a high impedance at the connection with the feeder. At lower frequencies, lumped components are preferred, such as an inductance formed by a section of the inner member between the connections to the sheath and feeder, this inner member section being surrounded by a body of high permeability material such as a ferrite ring. A resonating capacitor is coupled between a ground connection, which may be the sheath, and a conductor of the feeder which is connected to the inner member, so as to produce a parallel resonant structure at the operating frequency.

[0007] It is possible to construct an isolating structure which isolates the proximal end of the inner member from the feeder connection at two widely spaced operating frequencies, for instance, at an upper operating frequency above 300MHz and a lower operating frequency below 300MHz. Typical frequencies are 2.45GHz and 5MHz respectively.

[0008] In this case, two sections of the inner member which are electrically in series with each other constitute elements of respective resonant assemblies or units at the upper and lower frequency respectively. The first section may extend between the connection of the inner member to the feeder and a decoupling capacitance between the inner member and the sheath, while the second section extends between the decoupling capacitance and a d.c. connection of the sheath to the inner member, this latter connection being the furthest from the distal end of the inner member. The first section has the quarterwave electrical length feature described above, while the second section is surrounded by high permeability material so that the two sections respectively provide the impedance transformer and series inductance for isolation at the upper and lower frequencies. It will be understood that the decoupling capacitance represents a low impedance connection between the sheath and the inner member at the upper frequency, but not at the lower frequency. At the lower frequency, the first section appears as a low series impedance.

[0009] The insulating jacket between the conductive material of the inner member and that of the sheath may perform a dual function. insofar as not only does it provide a dielectric medium of a coaxial transmission line comprising the inner member as an inner conductor and the sheath as an outer shield, but also it may serve as an optical path for illumination of the operation site ad-

jacent the distal end of the inner member or for viewing of the site, the instrument acting as an endoscope. Thus, the space between the inner member and the sheath may be occupied by dielectric optical material such as glass or transparent plastics, formed as a tube, a rod, or as fibres. This optical material may also serve as a support for the inner member within the sheath.

[0010] According to a second aspect of the invention, there is provided an electrosurgical instrument for electrosurgical treatment at an operating frequency of at least 300MHz, comprising an elongate electrically conductive lumen housing a mechanically or optically functional element, an electrode at a distal end of the lumen and electrically coupled to the lumen, an elongate electrically conductive outer sheath coaxially arranged around the lumen and having a distal end adjacent the lumen distal end, the sheath being dimensioned to enclose an insulative layer (which may be air) such that the sheath and the lumen together form a coaxial transmission line, and an isolating structure associated with the distal end of the sheath to restrict the flow of electrosurgical currents in the sheath.

[0011] According to a second aspect of the invention, there is provided an electrosurgical tool converter for converting an elongate surgical tool into an electrosurgical instrument for performing electrosurgical treatment at an operating frequency of at least 300MHz, the converter comprising an elongate electrically conductive lumen for receiving the tool with a working element of the tool exposed beyond an open distal end of the lumen to form an electrode electrically coupled to the lumen, an elongate electrically conductive outer sheath coaxially arranged around the lumen and having a distal end adjacent the lumen distal end, the sheath being dimensioned to enclose an insulative layer such that the sheath and the lumen together form a coaxial transmission line, and an isolating structure associated with the distal end of the sheath to restrict the flow of electrosurgical currents in the sheath.

[0012] The isolating structure may comprise a balun, typically a quarter-wave sleeve balun, arranged to yield a substantially balanced feed location in the region of the distal end of the sheath where, generally, a working element of the instrument is attached, e.g. a pair of forceps jaws or scissor jaws.

[0013] In preferred embodiments of the invention, the sheath is proximally coupled to the lumen in respect of electrical currents at the operating frequency, and the lumen itself is coupled to a feed structure at a location spaced axially from the coupling to the sheath. The axial spacing is such that, at the operating frequency, the lumen may be electrically short-circuited to the sheath, the sheath and the lumen being isolated from the feed structure at that point at the operating frequency. Typically, the distance between the sheath-to-lumen coupling and the coupling of the feed structure to the lumen is a quarter-wavelength, the wavelength being the electrical wavelength of electrosurgical energy in the transmis-

sion line formed by the sheath and the lumen.

[0014] The axial distance between the feed structure and each discontinuity in the sheath, particularly the distal end of the sheath, is preferably such that the corresponding electrical length is one half wavelength or a multiple thereof in order that the transmission line formed by the sheath and the lumen need not have the same characteristic impedance as that of the feed structure. A multiple- $\lambda/2$  structure yields a source impedance at the end remote from the feed structure corresponding substantially to the characteristic impedance of the feed structure. Indeed, it is possible to construct the transmission line so as to have more than one section of different characteristic impedances due, for instance to the sheath having portions of differing diameters. In such circumstances, each section preferably has an electrical length which is an integer multiple of  $\lambda/2$ .

[0015] Delivering electrosurgical power at frequencies between 300MHz and 100GHz provides several advantages. The electrosurgical energy is propagated predominantly by dielectric means, which means that the conductive electrode/tissue interface is less important than at lower frequencies. By confining the electric field it is possible to define the treatment area in such a way that comparatively large areas may be treated with small electrodes. For cost benefit, particularly with regard to manipulable instruments such as forceps, the working elements can be constructed of a dielectric material with an embedded conductor rather than by more expensive metal fabrication techniques. UHF energy absorption, particularly at the ISM (Industrial/Scientific/Medical) frequency of 2450MHz, is determined by water content, which means that variable tissue performance is virtually eliminated. For example, in conventional low frequency electrosurgery, performance is determined by conduction. Fat can have a conductivity which is a mere fraction of highly conductive body fluids such as blood or bile. The water content values, however, are not very different and UHF performance is consequently not as variable.

[0016] The proximal trap and the distal balun referred to above allow electrosurgical currents to be isolated to selected areas of the instrument at UHF operating frequencies. Thus, even though the instrument may have electrical continuity throughout its construction due, for instance, to the lumen and the sheath being conductive throughout their length, only selected areas carry electrosurgical currents and voltages. For instance, the instrument, or a combination of the instrument and an inserted non-electrosurgical tool may have an exposed metal handpiece or handle with electrical continuity to the treatment area without danger to the user. This also means that the tool may be made entirely of metal, including a rod actuator and the like within the lumen, and may, therefore, be made more robust.

[0017] The sheath is typically fed from a proximally located lateral aperture by a coaxial transmission line or, at frequencies above 5GHz, a waveguide. The an-

nular cross-section space between the lumen and the sheath may contain a dielectric medium, which may include fibre optics or rod lenses for illumination and visualisation, and fluid passageways for fluid delivery or extraction.

[0018] The selective coupling of UHF electrosurgical energy, as described above, allows conversion of standard laparoscopic instruments or endoscopes, for electrosurgical use on tissue. The invention is also applicable to laparoscopic electrosurgical instruments. Thus, there may be provided, in accordance with the invention, an electrosurgical instrument comprising the combination of a tool converter as mentioned above and a surgical tool housed in the lumen, the tool having a working element projecting beyond the distal end of the lumen to form an electrode for electrosurgical treatment of tissue, and a handpiece projecting beyond a proximal end of the lumen.

[0019] The instrument may be adapted to operate additionally at comparatively low frequencies, i.e. below 300MHz and typically between 100 kHz and 40MHz. In this case a choke may be placed around the lumen at a proximal end of the transmission line formed by the sheath and the lumen, to prevent conduction of low frequency electrosurgical currents proximally along the lumen or the shaft of a surgical tool housed in the lumen. The same feed structure may be used for delivering both low frequency and UHF electrosurgical energy. The choke forms a lumped impedance circuit, and the return path back to the r.f. source connected to the feed structure from the tissue is by way of stray capacitance between the patient and the return conductor, which may be referenced to ground potential.

[0020] The invention will now be described by way of example with reference to the drawings in which:-

Figures 1A and 1B are longitudinal and transverse cross-sections of a first tool converter with accordance with the invention, for operation at 2450MHz; Figures 2A and 2B are similar cross-sections of a modified version of the tool converter of Figure 1; Figures 3A and 3B are similar cross-sections of a tool converter having a waveguide feed structure; Figures 4A and 4B are cross-sections of a tool converter similar to that shown in Figures 2A and 2B, but having the ability to operate additionally at frequencies in the region of 100kHz to 40MHz; and Figure 5 is a diagram showing the tool converter of Figures 4A and 4B connected to an electrosurgical generator.

[0021] Referring to Figure 1, apparatus for converting a laparoscopic surgical tool into an electrosurgical instrument comprises an internal lumen 1 in the form of an elongate conductive tube, and an elongate electrically conductive outer sheath 2 coaxially arranged around the lumen 1 and having a distal end 2D adjacent the lumen distal end 1D. The sheath 2 is dimensioned

to enclose an insulative layer 3 such that the sheath and the lumen together form a coaxial transmission line extending from a feed structure 4 to the distal end 2D of the sheath 2 where the lumen 1 has a projecting distal end portion terminating in distal end 1D. The distal end portion of the sheath 2 is configured as an isolating structure in that, in this embodiment, the sheath has an inner distal end portion of reduced diameter formed as a tube 5 within the main tubular body 6 of the sheath. The tube 5 is electrically connected at its proximal periphery to the main body 6 at a position such that the main body 6 and the inner portion 5 are in an overlapping configuration with a thin annular space between them. This space may be occupied by a material (not shown) having a different dielectric constant than that of the medium within the main sheath interior 3. The electrical length of the overlapping portion is arranged to be a quarter-wavelength, or an odd multiple quarter-wavelength so that the main body 6 of the sheath 2, where it overlaps the inner portion 5, forms a sleeve balun promoting a generally balanced condition where the lumen 1 emerges from the sheath at its distal end 2D. This structure, in conjunction with a low impedance connection 7 (in this case an electrical short circuit) between the sheath at its proximal end 2P and the lumen 1, allows an electrosurgical field to be developed at the distal ends of the lumen and the sheath whilst maintaining substantially ground potential along the length of the sheath proximally of the balun.

[0022] It will be noted that the r.f. feed structure 4 comprises a coaxial feeder with an inner conductor 41 passing through a lateral aperture 8 in the sheath 2 to a connection with the lumen 1 at a point spaced from the low impedance connection 7. This spacing ("B") is an odd multiple of the quarter-wavelength  $m\lambda/4$  (m is preferably equal to 1), allowing the isolation of the lumen 1 distally of the feed structure 4 from ground, given that the lumen is grounded at its proximal end by virtue of its connection to the sheath 2 which is connected to the screen of the r.f. feed 4.

[0023] Typically, the characteristic impedance of the feed structure or feeder 4 is 50 ohms. The transmission line formed by lumen 1 and sheath 2 (including the inner distal end portion 5), has two sections of two different characteristic impedances. The first of these sections, extending from the feeder 4 to the proximal rim of the inner portion 5, has a first characteristic impedance, typically 10 ohms or less, whilst the second section, represented by the inner distal end portion 5 of the sheath, has a second characteristic impedance somewhat lower than that of the first portion. Since these characteristic impedances are different from that of the feeder and different from each other, the electrical lengths of the inner portion 5 and of the complete sheath 2 from the r.f. feed point to the distal end 2D of the sheath 2 are multiples of  $\lambda/2$  (the word "multiple" here being indicative of any integer from 1 upwards). This yields, at least approximately, an operating impedance at the distal end equal

to the impedance of the feeder 4. The interior passage 1P of the lumen 1 is dimensioned to receive a laparoscopic tool such as a pair of forceps, scissors, or, indeed, an endoscope. Other possibilities will be apparent to those skilled in the art. The tool is fitted in a manner not shown such that the working elements or working section project from the distal end 1D of the lumen 1 and are electrically coupled to the lumen 1 so as to form an active electrode for electrosurgical treatment of tissue.

[0024] Electrosurgical power coupling at UHF or above may be indirect, by means of capacitive or inductive coupling between the lumen 1 and the inserted tool.

[0025] Typically, such surgical tools are constructed of stainless steel, which is a relatively poor electrical conductor. The lumen 1 is plated with silver or copper on its outer surface. Alternatively, in a case where the lumen 1 forms the shaft of a surgical tool itself, that shaft may have a silver or copper-plated outer layer.

[0026] The sheath 2 may be separated from the lumen 1 by low loss dielectric spacers (not shown), or the space 3 may be occupied by dielectric optical fibres or rods which, as well as performing an optical function for illumination and/or visualisation of the operative site, serve to support the lumen within the sheath.

[0027] The diameter of the sheath is largely governed by the required characteristic impedance. It should be borne in mind that Figure 1 is diagrammatic and is not intended to be a scale drawing. For a characteristic impedance of 50 ohms or upwards, the ratio between the inner diameter E of the sheath and the outer diameter F of the lumen is quite high, to the extent that the structure shown in Figure 1 could have a diameter typically three times that of the surgical tool inserted in it. In the case of the space 3 between the lumen 1 and the sheath 2 being used for optical fibres or a fluid conduit, this high ratio may be advantageous. However, coagulation performance is often improved by use of a lower characteristic impedance, the target tissue having an impedance typically lower than 50 ohms. In these circumstances, the ratio of the sheath inner diameter to the lumen outer diameter (i.e. E/F) can be reduced. Indeed, the sheath may have a characteristic impedance as low as 10 ohms, resulting in an instrument diameter in the order of only 20% to 30% greater than that of the inner diameter of the lumen 1 (typically accepting a 4-French or 5-French tool).

[0028] Preferably, a quarter-wave transformer section (not shown) comprising a transmission line of intermediate characteristic impedance is inserted in series between the 50 ohm feeder 4 and the aperture 8 to match the characteristic impedance of the combination of the sheath 2 and the lumen 1 to that of the feeder 4. This transformer may be part of the feeder itself integrated in the tool converter structure which includes the sheath 2. This avoids the standing waves produced when there is an impedance mismatch, even though the effects of these can be ameliorated by using half-wavelength structures as described above. As is well known in the

art, the impedance of such a transformer (which is not shown in the drawings), is the geometric mean of the two impedances being matched.

[0029] A modified version of the apparatus of Figure 1 is illustrated in Figure 2. Referring to Figure 2, the quarter-wave balun is formed differently from that of Figure 1 inasmuch as the sheath 2 has a constant internal diameter between the feeder 4 and the sheath distal end 2D. Instead of providing an inner distal end section as in the Figure 1 embodiment, the sheath 2 is provided with a quarter-wave sleeve 15 having one rim electrically connected with the main body of the sheath 2, its other rim being open circuit, with the electrical length of the thin annular space between the two components being equal to  $\lambda/4$  in the axial direction. Again, the sheath projects distally some distance beyond the balun section, and the lumen 1 projects distally beyond the distal end of the sheath 2D, where it is supported by an insulative annulus 16.

[0030] Again, in this embodiment, the preferred total electrical length of the sheath 2 between the feed 4 and the distal end 2D is a multiple of the half-wavelength.

[0031] Referring to Figure 3, an alternative embodiment for use at frequencies typically above 5GHz has a waveguide feeder 4W. The cross-sectional dimensions of the waveguide are inversely proportional to the operating frequency, and the waveguide may be filled with a low-loss dielectric material having a dielectric material having a dielectric constant greater than that of air in order to reduce the dimension further. Energy from the waveguide feeder 4W is coupled into the coaxial transmission line is coupled through the lateral aperture 8W in the sheath 2, and thereby coupled to the transmission line formed by the combination of the lumen 1 and the sheath 2. A tubular lateral stub 20 with a short circuited end provides a match between the two transmission line types.

[0032] In some circumstances, it can be advantageous to be able to supply electrosurgical energy to a treatment electrode at both UHF or upwards and at a lower frequency using the same instrument. Indeed, it may be advantageous to supply both frequency components simultaneously. This possibility is allowed for in the embodiment of Figure 4, which is of similar construction to that described above with reference to Figure 2, but with the additional feature of a high impedance series element between, on the one hand, the connection of the feeder 4 to the central lumen 1 and, on the other hand, the lumen at the proximal end of the sheath 2. In order to achieve operation at lower frequencies (typically 100kHz to 40MHz), but also at frequencies generally below 300MHz, a conductive path is provided between the inner surface of the lumen 1 and the inserted instrument shaft (not shown). Electrosurgical energy at UHF is isolated from the proximal end of the sheath and the instrument, as in the embodiments described above with reference to Figures 1 to 3, by interconnecting the lumen 1 and the sheath 2 with a low impedance element

at an electrically appropriate distance from the feeder 4. In the present embodiment, where a low frequency voltage needs to be developed between the lumen 1 and the sheath 2, the low impedance element is formed as a shunt capacitor 25 which is virtually a short circuit at UHF. Typically the capacitor may comprise a dielectric annulus around the lumen 1, so that the opposed sheath 2 and the lumen 1 in this region form a capacitor of sufficiently high value. The low frequency component is independently isolated from the proximal end of the sheath and the instrument by a metallic short circuit in the form of a conductive end plate 30 between the lumen 1 and an enlarged portion 2E of the outer sheath 2, and a series inductance formed by (a) the section 31 of the lumen 1 between the capacitor 25 and the end plate connection 30 and (b) a ring 32 filling the space between the sheath wall of the enlarged portion 2E and the inner lumen 1. The ring 32 is made of a magnetisable material having high permeability, such as a nickel-zinc-ferrite mixture. By way of example, a suitable material for operation at 5MHz is FairRite nickel-zinc-ferrite mix #61, which has a relative permeability of 120, and a Q in excess of 100 at 5MHz. The resulting series impedance is the product of the angular frequency, the relative permeability of the ferrite slug 32 and the effective area of the magnetic flux part of the cross-section divided by the effective magnetic flux path length. In this case, a slug of length 30mm (dimension G), outer diameter 28mm, and a lumen outer diameter (E) of 2.3mm, yields an inductive reactance of 40 ohms between the active and ground conductors of the feed 4 at 5MHz. In order that the inductance 31, 32 forms a resonant circuit at the lower operating frequency, a capacitance is connected between the sheath 2 and the conductor 41 of the feeder 4 connected to the lumen 1.

[0033] Referring to Figure 5, which diagrammatically shows the instrument described above with reference to Figure 4 connected to a dual frequency electrosurgical generator, the capacitance which resonates with the inductance 31, 32 at the lower operating frequency may be constituted by the feeder cable 34 itself and/or a lower frequency tuning reactance 36 (which may be capacitive or inductive, depending on the reactance of the cable 34) located in the feeder or, as shown in Figure 5, in the generator 40.

[0034] The generator comprises two electrosurgical r.f. sources in the form of a first UHF source 32 operating at 2.45GHz, and a second, LF, source 44 operating typically at 5MHz. Each has a respective output line 42A, 44A feeding a combiner 46 which has an output 46A forming the output of the generator 40, which is connected to the feeder 4. The tuning reactance for low frequency isolation of the proximal end of the instrument here comprises a shunt reactance 36 in the line 44A. The two r.f. sources 42, 44 are controlled by a controller module 48 within the generator 40 which, in turn, has an input 48A coupled to a foot switch or handpiece switch 50 for actuating the generator.

## Claims

1. An electrosurgical instrument comprising:-
  - an elongate inner tubular member having a proximal end and a distal end, at least a portion of the member being electrically conductive in order that there is d.c. electrical continuity between the said ends; and
  - an elongate tubular electrically conductive sheath surrounding the inner member but spaced from the conductive material of the inner member to form an electrically insulative jacket, whereby the inner member and the sheath constitute a coaxial transmission line, the sheath being electrically coupled to the inner member at a location spaced proximally from the distal end;
  - a feeder coupled to the inner member distally of the connection between the sheath and the inner member; and
  - an r.f. isolating structure between the said couplings of the inner member to the feeder and to the sheath, the isolating structure presenting a series impedance between the said connections at an operating frequency of the instrument.
2. An instrument according to claim 1, wherein the isolating structure comprises a section of the inner member between the said couplings, the section having an electrical length of  $m\lambda/4$ , where m is an odd number and  $\lambda$  is the wavelength associated with the operating frequency.
3. An instrument according to claim 1, wherein the isolating structure includes an inductance formed by a section of the inner member between the said couplings, the section being surrounded by a body of high permeability material.
4. An instrument according to claim 3 operable at upper and lower operating frequencies, wherein the isolating structure includes a further section of the inner member extending between the feeder and a decoupling capacitance, which capacitance is connected between the inner member and the sheath at a location between the feeder and the said inner member section surrounded by the high permeability body, the further inner member section having an electrical length of  $m\lambda/4$ , where m is an odd number and  $\lambda$  is the wavelength associated with the upper operating frequency.
5. An instrument according to any preceding claim, wherein the isolating structure is resonant at an operating frequency of the instrument.

6. An instrument according to claim 3 or claim 4, further comprising a capacitor coupled between the sheath and a conductor of the feeder connected to the inner member, the capacitor resonating with the said inductance at an operating frequency of the instrument. 5
7. An instrument according to any preceding claim, wherein the insulative jacket includes a dielectric optical material for transmitting illumination to the distal end of the inner member or for conveying imaging radiation from the distal end to the proximal end of the inner member. 10
8. An instrument according to any preceding claim, including a surgical tool having a metallic shaft housed inside the said tubular inner member, the tool including a movable working element projecting from the distal end of the inner member and electrically coupled to the conductive material of the inner member. 15 20
9. An electrosurgical instrument for electrosurgical treatment at an operating frequency of at least 300MHz, comprising an elongate electrically conductive lumen housing a mechanically or optically functional element, an electrode at a distal end of the lumen and electrically coupled to the lumen, an elongate electrically conductive outer sheath coaxially arranged around the lumen and having a distal end adjacent the lumen distal end, the sheath being dimensioned to enclose an insulative layer such that the sheath and the lumen together form a coaxial transmission line, and an isolating structure associated with the distal end of the sheath to restrict the flow of electrosurgical currents in the sheath. 25 30 35
10. An instrument according to claim 9, wherein the isolating structure comprises a balun arranged to yield a substantially balanced feed location in the region of the distal end of the sheath. 40
11. An instrument according to claim 9 or claim 10, wherein the balun is a quarter-wave sleeve balun. 45
12. An instrument according to any of claims 9 to 11, wherein the sheath is proximally coupled to the lumen in respect of electrical currents at the operating frequency, and the lumen is coupled to a feed structure at a location spaced axially from the said coupling to the sheath by a distance which is such that portions of the lumen extending proximally of the said coupling are electrically isolated from the feed structure at the operating frequency. 50 55
13. An instrument according to claim 12, wherein the feed structure includes a lateral aperture in the sheath.
14. An instrument according to claim 12 or claim 13, wherein the axial distance between the feed structure and the distal end of the sheath corresponds to an electrical length of substantially  $n\lambda/2$ , where  $n$  is an integer (1, 2, 3,...) and  $\lambda$  is the wavelength in the said coaxial transmission line at the operating frequency.
15. An instrument according to any of claims 12 to 14, including a low frequency isolating choke associated with the lumen proximally of the feed structure, the choke being effective at a second operating frequency of less than 40MHz.
16. An electrosurgical tool converter for converting an elongate surgical tool into an electrosurgical instrument for performing electrosurgical treatment at an operating frequency of at least 300MHz, comprising an elongate electrically conductive lumen for receiving the tool with a working element of the tool exposed beyond an open distal end of the lumen to form a elongate electrically conductive outer sheath coaxially arranged around the lumen and having a distal end adjacent the lumen distal end, the sheath being dimensioned to enclose an insulative layer such that the sheath and the lumen together form a coaxial transmission line, and an isolating structure associated with the distal end of the sheath to restrict the flow of electrosurgical currents in the sheath.
17. A tool converter according to claim 16, wherein the isolating structure comprises a balun arranged to yield a substantially balanced feed location in the region of the distal end of the sheath.
18. A tool converter according to claim 16 or claim 17, wherein the balun is a quarter-wave sleeve balun.
19. A tool converter according to any of claims 16 to 18, wherein the sheath is proximally coupled to the lumen in respect of electrical currents at the operating frequency, and the lumen is coupled to a feed structure at a location spaced axially from the said coupling to the sheath by a distance which is such that portions of the lumen extending proximally of the said coupling are electrically isolated from the feed structure at the operating frequency.
20. A tool converter according to claim 19, wherein the feed structure includes a lateral aperture in the sheath.
21. A tool converter according to claim 19 or claim 20, wherein the axial distance between the feed structure and the distal end of the sheath corresponds

to an electrical length of substantially  $n\lambda/2$ , where  $n$  is an integer (1, 2, 3,...) and  $\lambda$  is the wavelength in the said coaxial transmission line at the operating frequency.

5

22. A tool converter according to any of claims 19 to 21, including a low frequency isolating choke associated with the lumen proximally of the feed structure, the choke being effective at a second operating frequency of less than 300MHz.

10

23. A tool converter according to claim 22, where the choke is effective at an operating frequency of less than 40MHz.

15

24. An electrosurgical instrument comprising the combination of a tool converter as claimed in any of claims 16 to 23, and a surgical tool housed in the lumen, the tool having a working element projecting beyond the distal end of the lumen to form an electrode for electrosurgical treatment of tissue, and a handpiece projecting from a proximal end of the lumen.

20

25. A laparoscopic instrument according to claim 24.

25

26. An instrument according to claim 24 or claim 25, having a reciprocable actuation rod connected to a distal movable working element.

30

27. An instrument according to claim 26, constructed as forceps.

28. An instrument according to claim 26, constructed as scissors.

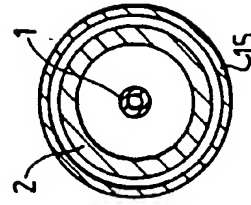
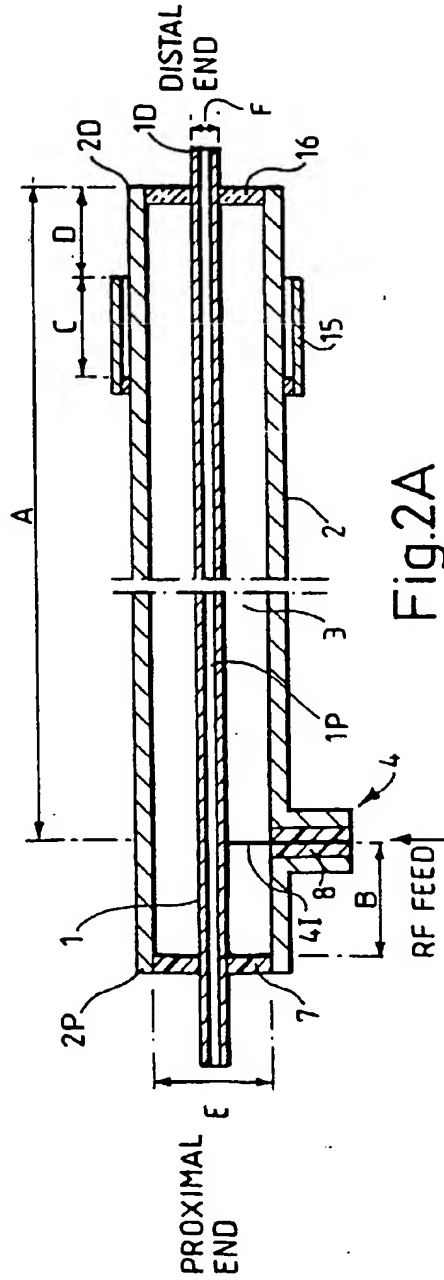
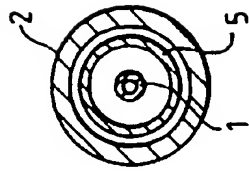
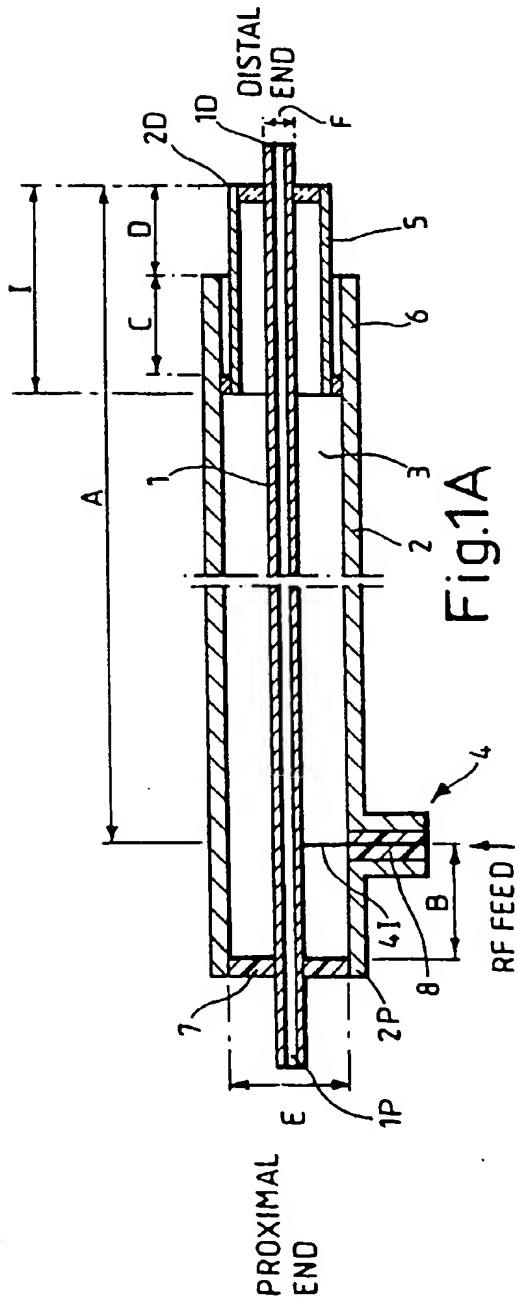
35

40

45

50

55



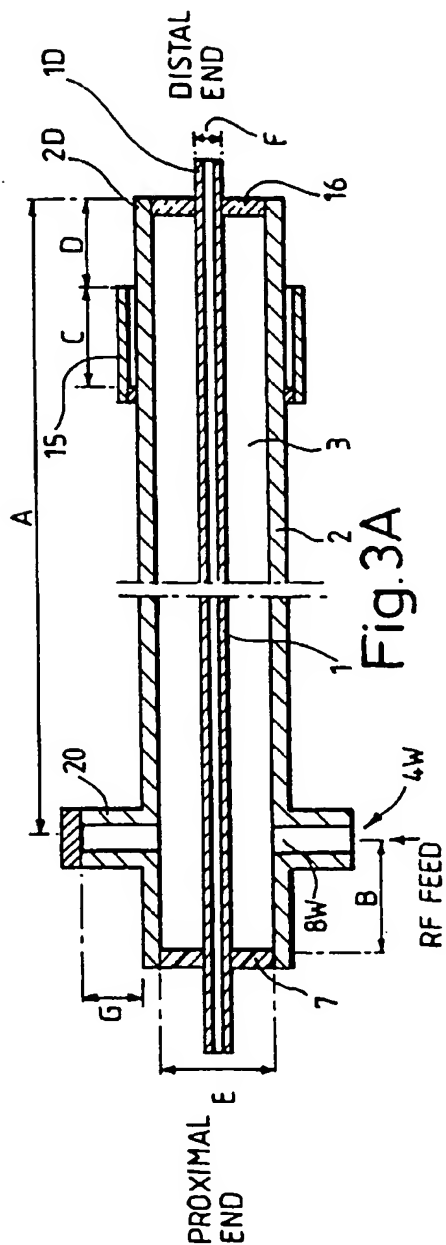


Fig. 3B

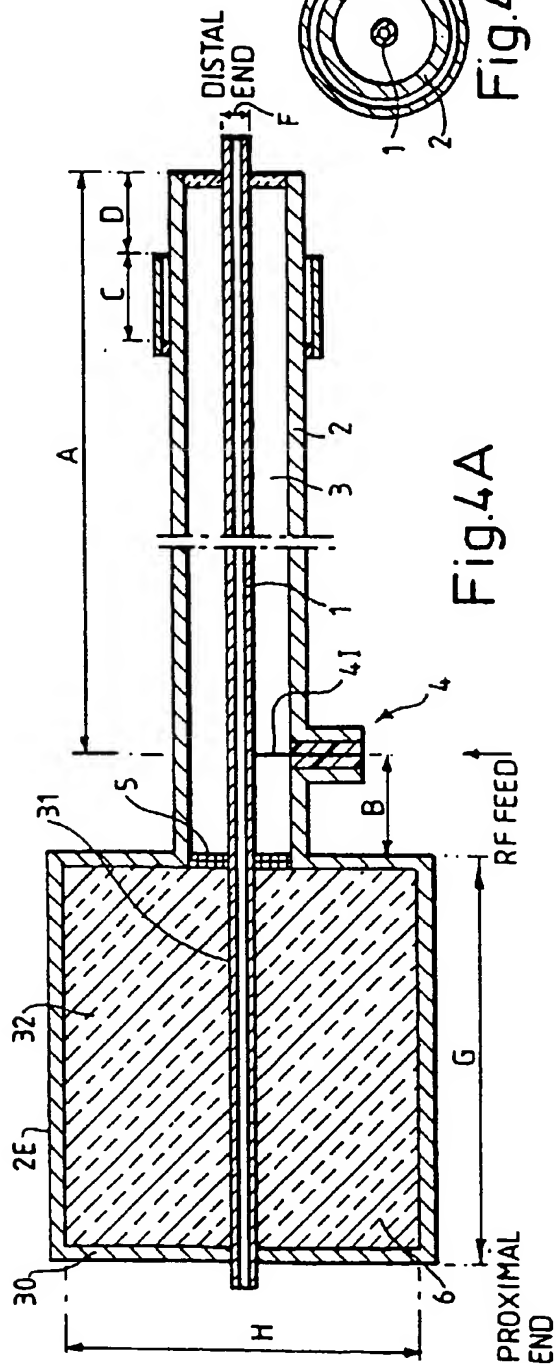
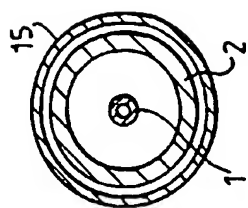


Fig. 4A

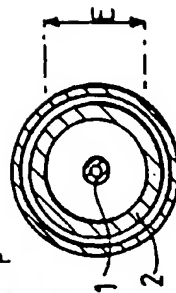
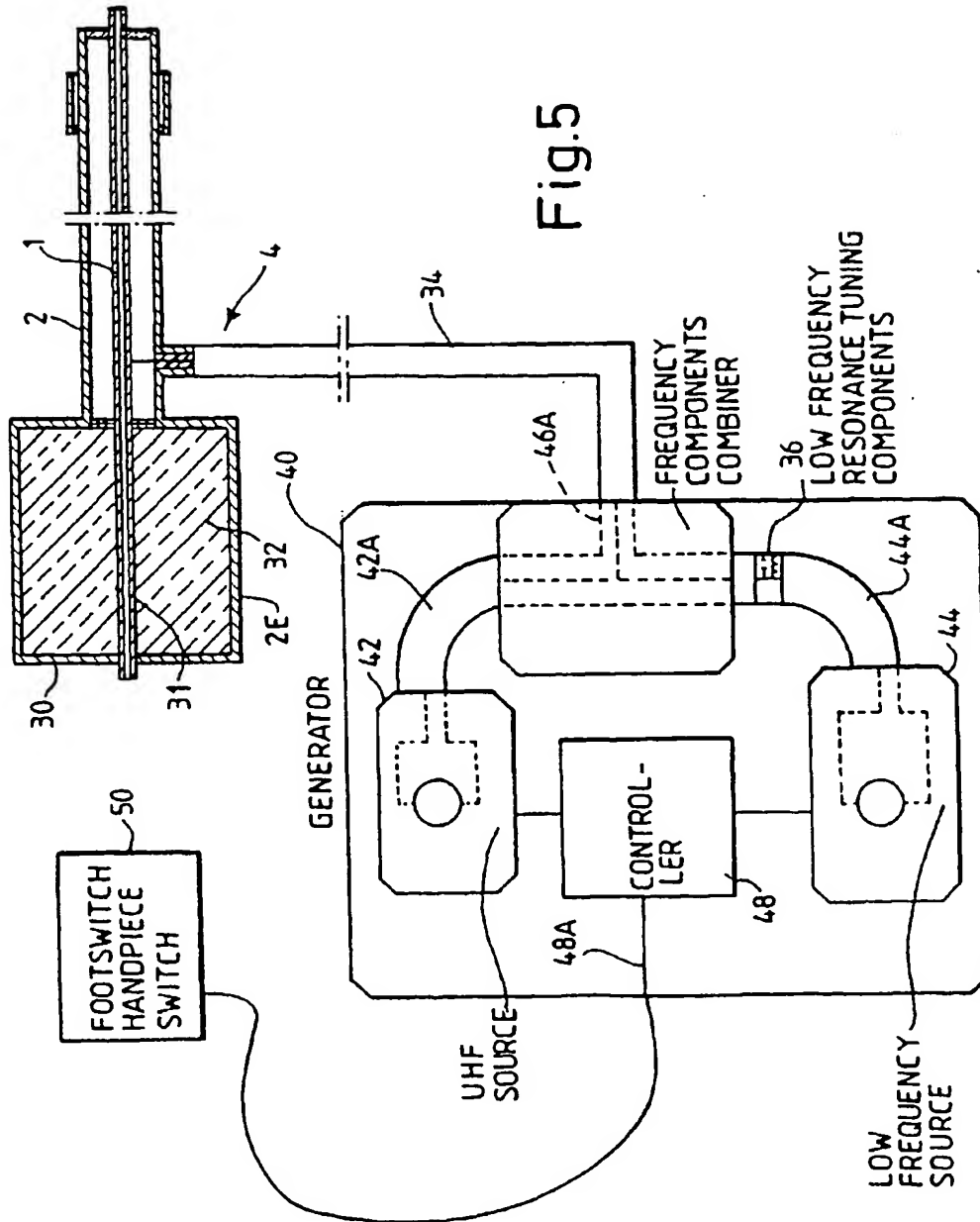


Fig. 4B





European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 00 30 4251

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 405 346 A (WARNER GLEN G ET AL) 11 April 1995 (1995-04-11) summary of the invention ---	1,9,16	A61B18/14
A	US 5 370 644 A (LANGBERG EDWIN) 6 December 1994 (1994-12-06) * column 8, line 15-41; figure 4 * ---	1,9,16	
A	US 4 116 198 A (ROOS EBERHARD) 26 September 1978 (1978-09-26) * column 4, line 50-65 * ---	1,9,16	
A	US 5 217 459 A (KAMERLING WILLIAM) 8 June 1993 (1993-06-08) * column 3, line 19-23 * * column 2, line 58-65; figures 1,2 * ---	1,9,16	
A	US 3 999 552 A (HUGGINS WILLIAM H) 28 December 1976 (1976-12-28) * column 2, line 13-28 * ---	1,9,16	
A	US 4 641 649 A (WALINSKY PAUL ET AL) 10 February 1987 (1987-02-10) * column 4, line 11-23; figure 2A * ---	1,9,16	TECHNICAL FIELDS SEARCHED (Int.Cl.7) A61B
A	EP 0 865 768 A (KASEVICH RAYMOND S) 23 September 1998 (1998-09-23) -----		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 5 September 2000	Examiner Papone, F
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 (03.02) (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 30 4251

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

05-09-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5405346 A	11-04-1995	US 5364392 A	15-11-1994
		AU 6912794 A	12-12-1994
		EP 0697842 A	28-02-1996
		WO 9426188 A	24-11-1994
		US 5693082 A	02-12-1997
		US 5957969 A	28-09-1999
US 5370644 A	06-12-1994	US 5246438 A	21-09-1993
		US 4945912 A	07-08-1990
		US 5257635 A	02-11-1993
		US 5230349 A	27-07-1993
		AT 150274 T	15-04-1997
		AU 4187893 A	23-09-1993
		AU 645486 B	20-01-1994
		AU 4660189 A	26-06-1990
		CA 2003689 A	25-05-1990
		DE 68927892 D	24-04-1997
		EP 0445223 A	11-09-1991
		EP 0745354 A	04-12-1996
		WO 9006079 A	14-06-1990
US 4116198 A	26-09-1978	DE 2521719 A	25-11-1976
US 5217459 A	08-06-1993	NONE	
US 3999552 A	28-12-1976	DE 2544378 A	16-12-1976
		FR 2311512 A	17-12-1976
US 4641649 A	10-02-1987	NONE	
EP 0865768 A	23-09-1998	US 6016452 A	18-01-2000
		CA 2232651 A	19-09-1998

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82